California Energy Commission
Public Interest Energy Research (PIER) Program
Renewables

Research Powers the Future

Solar Forecasting Reduces Renewable Integration Costs

June 2012

Fact Sheet

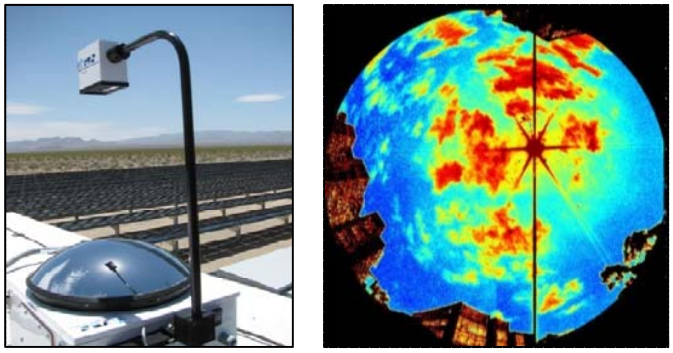
The Issue

Integration of large amounts of solar energy into the electricity grid poses challenges due to the variable nature of the solar resource. PIER's leadership in sponsoring solar forecast research will allow grid operators to better accommodate the variable electricity generation in their scheduling, dispatching, and regulation of power.

Project Description

California has many unique microclimates that require specific tools to accurately forecast cloud cover and solar power output. In coastal areas, home to the majority of rooftop solar power plants, marine layer clouds and the timing of burn-off are notoriously difficult to predict. Areas in the arid southeast and in the Central Valley are clearer, but Tule fog and winter storm systems need to be accurately forecast. The University of California, San Diego (UC San Diego) is home to the Center of Excellence in Renewable Resources and Integration, a premier research group on solar forecasting in the state.

With funding from the California Energy Commission and the National Science Foundation, Professor Coimbra explores experimental, analytical, and field work methods to develop new solar forecasting methods and technologies, including advanced forecasting engines, smart instruments, and supercomputing units for in-situ, real-time forecasts. He uses a network of solar observatories distributed throughout several University of California campuses to collect ground data for operational forecasts with time horizons varying from seconds to multiple days. Coimbra's lab develops methods for predicting cloud movements and their influence on renewable generation. He is now developing artificial intelligence (AI) solutions for receiver-to-storage and smart inverter control technologies.



Total sky imagery at utility scale solar power plants or in high photovoltaic penetration urban areas can warn solar grid operators of impeding ramps up to 25 minutes before they occur.
Image courtesy University of California, San Diego

One of the devices developed in the lab has made its way into the field, the total sky imagery camera. The total sky imagery camera and the associated sky imagery approach developed by Professor Kleissl, of UC San Diego, has the advantage of using very detailed information about the extent, structure, and motion of existing clouds near the solar generation facility. These data can be used to generate very short-term (minutes ahead) predictions of future cloud patterns in the vicinity of the plant. It is possible to extend the spatial scale by using multiple imagers at different locations.

The forecasting technologies will be developed and prototyped at the existing UC San Diego 42 MW microgrid. This advanced smart microgrid features

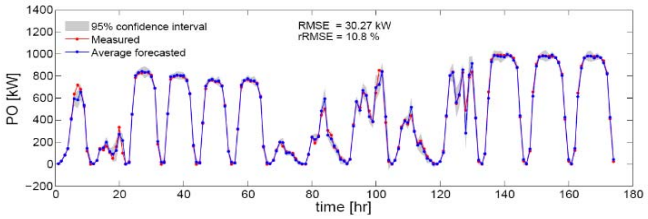
deep situation awareness for the California Independent System Operator (California ISO) and San Diego Gas & Electric Company (SDG&E). It represents much of the California urban areas and includes 16 densely spaced solar monitoring systems, a sky imager, and a ceilometer that produce solar output forecasts for 1.2 MW of dispersed photovoltaics (PV). These forecasts will be used by a microgrid scheduler and optimizer to enable supply, storage, and load adjustments based on dynamic market price signals. Each of these elements in and of themselves represents the leading edge of the current state of the art, but the assemblage of all three is globally unique.

Anticipated Benefits for California

UC San Diego's lab-to-market approach ensures that benefits to California materialize in the marketplace. This project is in collaboration with industry partners, with frequent input from representative of the California utility and California ISO. Over 10 graduate students and postdoctoral fellows are on track to become the next generation of highly skilled professionals in variable energy resource management.

In Germany, the development of accurate solar forecasting tools avoided the additional integration costs of requiring non renewable spinning reserve to support over 17 GW of Photovoltaics. Currently, solar forecasting can provide a very powerful short-term solution to enable higher PV penetration at fewer costs for system operators and ratepayers in California.

In a 2030 30% renewables penetration scenario "using state-of-the-art wind and solar forecasts reduced utility operating costs by up to 14%, or $5 billion/yr." The National Renewable Energy Laboratory Western Wind and Solar Integration Study, GE Energy (2010)



Hour-ahead solar farm power output forecasts generated with fractional evolutionary neural network engines dramatically improve over the accuracy obtained from satellites and numerical weather models.
Image courtesy University of California, San Diego

Project Specifics

Contract Numbers: 500-10-043 & PIR-08-036
Contractor: University of California, San Diego
City/County: San Diego, San Diego
Amount: $469,447 (500-10-043); $204,794 (PIR-08-36)
Co-funding: $140,000 (U.S. Department of Energy); $126,427 (National Renewable Energy Laboratory), $744,086 (Sanyo Electric Corp.), $190,872 (California Solar Initiative), $568,202 (National Science Foundation), $115,000 (CITRIS).
Term: August 2011 to December 2013
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